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Children's noun-pair learning as a function of subject-generated or experimenter-provided strings and response measure.

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CHILDREN'S NOUN-PAIR LEARNING AS A FUNCTION OF SUBJECT-GENERATED OR EXPERIMENTER-PROVIDED STRINGS AND RESPONSE MEASURE

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June, 1973

DEDICATION

To

Michele: Who had faith in me and provided me the emotional strength to complete this work.

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(June, 1973)

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Previously, no difference had been found in young children's learning of aurally presented concrete nouns when Ss were instructed to generate sentences linking the nouns, or the nouns were presented in a sentence text. Also, recognition as a response measure and certain response prompts facilitate learning relative to verbal recall.

One-hundred sixty middle SES, second graders were administered thirty pairs of line drawn representations of common nouns. Analysis of the two-factor design revealed: (a) strings provided to Ss facilitated learning more than subject-generated strings, (b) provided strings selected at random from the subject-generate pool facilitated learning more than strings selected from the pool to meet certain syntactic and semantic criteria, (c) scores were higher in prompted response conditions than unprompted, and (d) rated comprehensibility of provided sentences was highly correlated with number of correct responses.

The higher scores in the experimenter-provided condition are discussed in terms of a possible treatment by presentation modality interaction, while the response measure contrasts support the assumption that elaboration is the critical factor in noun pair learning.

CHAPTER I

Introduction

It has been approximately eight years since cows began chasing balls through the literature on paired--associate (PA) learning (Rohwer, 1966). While potentially disconcerting to the uninitiated, the "cow chasing ball" phenomenon has been precipitated by increased utilization of the PA paradigm for investigating the role that semantic and syntactic factors play in learning.

The PA task consists of a collection of discrete item pairs, presented successively to the learner. The discrete nature of the pairs is important, since unlike free recall and serial tasks, global memory and sequential memory appear less important for successful performance. The learner must, instead, focus on each pair as a separate unit, with the success of his performance dependent upon the degree to which stable associations within pairs are generated (Levin, 1971).

Prior to the recent explosion of studies investigating PA learning, it was argued that the task involved relatively elemental forms of learning, specifically rote memorization (Jensen, 1969). However, an accumulation of empirical evidence suggests that the learning of a PA list involves more than passive participation on the learner's part.

Interpretive subject reports obtained during and after learning indicate that proficient learners transform the PA itmes in order to render the pair more memorable (Martin, Boersma, and Cox, 1965; Paivio, Yuille, and Smythe, 1966; Schwartz, 1971).

The nature of this "transformation" process seems to be the generation of some event involving both items. Rohwer (1970) has termed the process "elaboration." He hypothesized that the critical determinant of performance levels in a noun-pair learning task is whether or not the subject generates an event as a shared referent for each pair of nouns. For example, the verbal elaboration of a noun pair presented aurally may be characterized by a S repeating the noun pair in a sentence describing an interaction involving the items (e.g., The S hears "cow-ball" and generated "The cow chased the ball"). According to the assumption that the existence of elaboration is a critical factor in successful noun pair learning, a major objective of inquiry has been to determine the conditions that control this elaboration process. Unfortunately, these conditions have been obscured by conflicting results which have emerged from a diversity of experimental designs, subjects, and materials employed in these investigations.

It has been reported that experimenter-provided (EP) or subject-generated (SG) sentences or phrases serving to relate paired-associate items to one another facilitate learning (Davidson, 1964; Reese, 1965; Rohwer, 1966; Rohwer, Lynch, Levin, and Suzuki, 1968; Rohwer and Bean, 1973). However, the relative facilitation of provided and generated verbal elaborations was found to vary as a function of such factors as age (Rohwer, Lynch, Levin, Suzuki, 1968; Kee, Guy and Rohwer, 1972; Rohwer and Bean, 1973) presentation mode (Kee, Guy, and Rohwer, 1972; Rohwer, Lynch, Levin and Suzuki, 1967) syntactic properties of elaboration (Rohwer, 1966; Rohwer and Levin, 1968; Ehri and Rohwer, 1969; Hughes and Walsh, 1971; Yuille and Pritchard, 1969; Rohwer and Lynch, 1967) response mode (Rohwer, Schuell, and Levin, 1967; Levin, 1970; Levin and Horvitz, 1971; Kee, Guy, and Rohwer, 1972; Bower and Winzenz, 1970; Rohwer and Lynch, 1966) and meaningfulness of elaboration (Rohwer and Levin, 1968; Duffy and Montague, 1970; Bobrow and Bower, 1969).

The principal objective, therefore, of the present research was to synthesize and extend previous findings regarding parameters shown to affect the facilitation of verbal elaborations. The specific parameters of interest were response measure, type of elaboration (experimenter-provided and subject-generated) and the syntactic and semantic properties of provided elaborations.

Bobrow and Bower (1969) compared experimenter-provide and subject-generate conditions with a group of college age Ss. They reported that Ss in a generate condition recalled more noun pairs relative to Ss in a provide condition, and that Ss in the control condition performed as well as Ss provided with elaborations.

The greater facilitating effect of generated relative to provided sentences with college age Ss has now been replicated by a variety of researchers (Schwartz, 1971; Bower and Winzenz, 1970; Pelton, 1969). Generally, the phenomenon has been explained in terms of greater S involvement in the generate condition, or the greater comprehensibility of self-generated strings.

Pelton (1969) argued that in studies comparing subject-generated vs. experimenter-provided sentences, it is necessary to use a yoking procedure. That is, sentence elaborations are matched between groups by giving each subject in the provide condition the sentences that had been constructed by a counterpart in the subject-generate condition. The rationale was that sentences provided to subjects might in some way be different than those generated by subjects.

The greater facilitating power of subject-generated sentences vs. experimenter-provided sentences appears to be a function of age. Rohwer and Bean (1973) and Bean and Rohwer (1971) compared subject-generated and experimenter-provided conditions at earlier age/grade levels, (i.e.,

grades 1,3,6,8,11). They used a 36-item aurally presented list. While both provided and generated sentences facilitated performance relative to a control, there was no significant difference between the generate and provide treatment conditions at a variety of grade levels (1,3,6,8) and types of populations (low SES black, low SES white, high SES white). This difference in findings suggests an age related developmental shift in the relative facilitation of experimenter-provided and subject-generated elaboration.

Kerst and Levin (1972) also compared generate and provide sentence conditions with an elementary school population (4th and 5th grade Ss). Using a 20-item list of pictured pairs with aurally presented labels and a four-second exposure time, they replicated the earlier finding of the equivalent facilitation of subject-generated and experimenter-provided sentences.

In an attempt to explain this discrepancy in findings between elementary and college age subjects, Kerst and Levin (1972) noticed that performance in the subject-generated condition was considerably more variable than in the experimenter-provided condition. The nature of the variability difference was such that a greater proportion of very high, as well as very low scores was evidenced in the

subject-generate condition. They suggested that not all Ss at this age are adept at executing learning strategies on request, but those who do, benefit more than Ss who simply employ a strategy provided by someone else.

The Kerst and Levin data thus implies that at some younger age range, Ss provided with sentences may perform better than Ss asked to generate their own elaborations. The Rohwer and Bean (1973) finding of no difference between the effect of subject-generate and experimenter-provide conditions does not vitiate this possibility. Rohwer and Bean used an aurally presented list of PA items. The focus of this discussion concerning the age shift in the relative facilitation of subject-generate and experimenter-provided conditions has been on the modality of treatment, not on the modality of representing the items to be coupled. Nevertheless, as noted by Rohwer (1970), it is clearly possible to inquire into the effects of both kinds of modality contrasts, as well as to entertain the hypothesis that they may interact.

According to the elaboration assumption, performance improves with increasing emphasis on the event referents of the items to be coupled. Insofar as pictorial representations increase the likelihood of an event orientation in the learner, they should be associated with better performance than word representations. Evidence from certain PA experiments using young Ss gives some support to this notion

(Dilly and Paivio, 1968; Rohwer, Lynch, Levin, and Suzuki, 1967; Lynch and Rohwer, 1971). Specifically, Lynch and Rohwer (1971) found that associative matching was higher in a picture than a word condition, especially when accompanied by a sentence context. This data suggests that presentation mode may be an important factor in comparisons of subject-generate and experimenter-provide treatments with young children. Perhaps the nonsignificant difference between the generate and provide conditions found by Rohwer and Bean (1973) and Kerst and Levin (1972) would change if young Ss were asked to learn a pictorial rather than aural list of PA's.

In addition to age, the degree to which provided elaborations affect learning has been found to vary as a function of their syntactic composition. The syntactic properties of strings used in the experimenter-provide conditions have been analyzed rather extensively. The term "string" is meant to denote either sentences, phrases, or clauses. For example, the form class of words that join PA items has a differential facilitating effect (Rohwer, 1966). Rohwer presented Ss with PA items joined by verbs, prepositions, and conjunctions; e.g., 1) The cow ate the corn (verb), 2) The cow on the corn (preposition), and 3) The cow and the corn (conjunction). He found that all three provide conditions facilitated performance relative to a

control. However, verb/joiners create the greatest degree of facilitation, followed by prepositions and conjunctions respectively.

Hughes and Walsh (1971) in a developmental study also compared PA's joined by conjunctions, verbs, or prepositions and replicated Rohwer's (1966) results with 6th grade Ss. With 2nd and 4th grade Ss, there was no significant difference between verbs and prepositions, although both verbs and prepositions facilitated learning more than conjunctions.

Within the form class, verb effect, Rohwer and Levin (1968) found that verbs implying relatively little overt activity between noun pairs facilitate learning as much as verbs implying considerable activity. Finally, Ehri and Rohwer (1969) found no difference in the degree to which one and two unit verbs (e.g., one unit - "The tractor hit the apple." two unit - "The tractor ran over the apple.") facilitate learning.

Taken together, these findings suggest that when elementary school Ss are provided with simple active declarative sentences those sentences facilitate Ss learning of PA items relative to a control group. The findings also suggest that the simple active declarative sentence can have either a one unit or two unit verb.

Semantic factors, specifically the meaningfulness of provided elaborations have also been shown to affect the degree of learning. Rohwer (1966) previously found that scrambled strings (e.g., "roses hats drink) did not facilitate performance compared to normal sentences. Similarly, Rohwer and Levin (1968) investigated meaningfulness by comparing normal (e.g., roses drink rain), and anomalous sentences (e.g., roses drink hats). Not unsurprisingly, normal sentences produced facilitation of PA learning relative to anomalous sentences.

Duffy and Montague (1970) investigated meaningfulness with a different procedure. They examined the relationship between rated "meaningfulness" and "imagery" of experimenter provided sentences and performance when those sentences were provided to college age Ss in a PA task. This was an attempt to explain further what it is about the semantic properties of provided sentences that affect performance. These researchers operationalized "meaningfulness" and imagery value by asking Ss to rate these parameters of sentences on a five point rating scale. Subjects rating "meaningfulness" were instructed to rate the sentences according to "how much sense" the sentences made.

Duffy and Montague found that rated "meaningfulness" of sentences was significantly positively correlated with number correct on the PA task, while the correlation between

performance and imagery value was nonsignificant. While Duffy and Montague did not experimentally manipulate "meaningfulness," the significant relationship is supported by Rohwer (1966) and Ehri and Rohwer (1969).

The research reviewed to this point has dealt with variables which pertain to the input phase of learning. The learning of PA's also varies according to variables which affect retrieval conditions.

Typically, on a PA task where the items are concrete nouns, scores when the response measure is recognition are higher than when the response measure is verbal recall (Kee, Guy, Rohwer, 1972; Bower and Winzenz, 1970). This relationship has obtained under variations in subject grade level (2nd, 4th, 5th, 7th, college) and presentation mode (pictorial, verbal, and mixed list).

Rohwer, Schuell, and Levin (1967) utilized a prompted recall condition. During the test trial, the stimulus noun was presented in the context of the string provided the S on the study trial (minus the response term). This condition was the same as the recall with prompt condition used in the present experiment. Subjects receiving the prompt learned more pairs than Ss in unprompted recall condition. Other researchers (Levin and Horvitz, 1971) have demonstrated a relationship between the nature of a prompt, and the degree to which it facilitates learning. Specifically, a prompt which reinstates the study trial sentence context minus the

response noun facilitates learning more than a prompt wherein the study trial context is changed. For example, Levin and Horvitz (1971) found that if the S was provided on the study trial with "The girl grabs the ball," the test trial prompt "The girl grabs the _____" facilitated learning more than "The girl or the _____." Ehri and Rohwer (1969) also found the prompt effect. However, Rohwer and Levin (1968) and Levin (1970) found no difference between scores when comparing test trial scores of N + V (noun + verb) and N (noun) conditions. Levin (1970) felt that procedural differences may explain these findings.

The assumption that the existence of elaboration is a critical factor in learning offers an attractive method of explaining the results obtained from experiments varying retrieval conditions. The elaboration assumption implies that the greater the degree to which the elaborated event is reactivated, the better the performance. Accordingly, recognition as a response measure, and certain prompted response modes, should affect the reactivation of the event to a greater degree than unprompted verbal recall. Recognition eliminates the factor of response term availability, and the presence of the response term may cue the regeneration of the original elaborated event. Similarly, prompted response modes which incorporate a restatement of the original event should aid in the reactivation of the original event.

In summary, several areas seemed suitable for investigation in the present study. Research comparing subject-generated and experimenter-provided elaborations indicated a developmental shift in their relative facilitation. The age trend indicated that at some young age range, provided elaborations might facilitate learning to a greater degree than subject-generated elaborations. While this had not been demonstrated in a study using an aurally presented PA list, certain research suggested that the relationship might change if Ss were presented with pictorial items. The nature of the particular syntactic and semantic features of provided elaborations which affect learning was also unclear. Generally, examinations of syntactic factors had manipulated one syntactic variable at a time to assess its affect on learning. This systematic procedure isolated certain syntactic variations which seemed to aid learning. While necessary, this technique gave no indication of how a composite of these critical syntactic and semantic factors might behave.

Further, rated meaningfulness of provided elaborations was found to be positively related to learning. Yet this relationship was investigated with adult Ss. The developmental shift in the relative facilitation of experimenter-provided and subject-generated elaborations indicates the inappropriateness of generalizing adult findings to children.

Finally, studies which varied response measure and response prompts have generally supported the elaboration assumption. That is, the more likely the original elaborated event is reactivated, the better the performance. Yet, variations in response measure and retrieval prompts affect this reactivation in different ways, and the relationship between the two was unclear and untested.

Statement of the Problem

The problems addressed by the present study are:

a. To examine the relative facilitation of subject-generated and experimenter-provided elaborations with a sample of young children.

b. To compare the relative facilitation of two types of provided elaborations which varied on certain syntactic and semantic dimensions.

c. To examine the relationship between the response measures recall and recognition and retrieval prompts.

d. To determine the correlation between rated comprehensibility of sentences and the degree to which they facilitate learning in an experimenter-provide condition.

CHAPTER II

Method

Subjects. Subjects were drawn from the second grade population in two elementary schools. Both schools were situated in suburban residential neighborhoods serving a middle socio-economic status white population. One hundred-sixty children were randomly selected and assigned to one of sixteen experimental conditions. An additional thirty children were randomly selected from the same population and served as a rating group to determine the "comprehensibility" ratings of sentences used in one of the experimenter-provided conditions. Subjects in the rating group did not participate in the main experiment.

Design of Experiment. The design was a completely randomized two-factor design with four levels of treatment (empty control, subject-generate, experimenter-provide random, experimenter-provide criteria), four levels of response mode (verbal recall, verbal recall with prompt, recognition, recognition with prompt), and ten observations per cell. The dependent variables were the number of correct response nouns either recalled or recognized on two separate test trials. Since the design incorporated multiple dependent variables, the analysis posed interesting problems for the experimenter. Generally, there are four methods used for analyzing such data.

1. To split the analysis into two parts and perform a univariate analysis of variance for each dependent variable.
2. To analyze the data using univariate analysis of variance procedures for a repeated measures design.
3. To create a third variable (such as the difference scores between the two variables) and analyze the data using the univariate ANOVA model.
4. To analyze the data using the multivariate analysis of variance model.

Bock (1968) suggests that when univariate tests, such as F-tests, are performed on each variable separately (as in case 1 above) a single probability statement applicable to all variables jointly cannot in general be obtained from the separate F ratios.

These dependent variables are correlated in some arbitrary and unknown way, and the separate F-tests are not statistically independent. No exact probability that at least one of them will exceed some critical level on the null hypothesis can be calculated. Multivariate tests, on the other hand, are based on sample statistics which take into acccunt the correlations between variables and have known exact sampling distributions from which the required probabilities can be obtained.

The univariate ANOVA model applied to repeated measures (case 2 above) rests upon rather stringent assumptions concerning the form of the data. For example, a basic assumption of ANOVA involves homogeneity of variance, that is, the error variances for levels of a factor are assumed to be equal.

Also, in a multifactor design, all the covariances between the various treatments are assumed to be equal. Box (1954) has indicated that the usual F-test in the case of uncorrelated data is relatively robust (insensitive) with respect to violation of the assumption of homogeneity of variance (especially with an equal number of subjects in each cell of the design). That is, for uncorrelated data, violation of the assumption of homogeneity of variance does not seriously bias the final F-test. (Winer, 1971).

Box (1954) has shown, however, that heterogeneity of both the variances and covariances in a design having correlated observations will generally result in a positive bias in the F-test. That is, the critical value obtained from an F-table tends to be too low relative to a critical value appropriate for an arbitrary variance-covariance matrix.

Analysis through creation of a third variable (case #3) has the undesireable property of masking the relative contribution of the variables combined. Implicit in the

creation of the third variable is the assumption that each of the original variables are equally weighted. In fact, this may or may not be the case.

Due to the potential problems which exist in the analysis of designs incorporating multiple dependent variables by the univariate ANOVA model, the MANOVA model was employed to analyze the data in the present study. The MANOVA model does not rest upon the same assumptions about the variance-covariance matrix as ANOVA and as Bock (1968) suggests it is particularly suited for analyzing data from repeated measures designs since the sample statistics take into account the correlations between the variables.

Within the context of the MANOVA model, planned comparisons were formed to provide information concerning the major questions of the study. See Appendix A for the statement of statistical hypotheses, and Appendix B for the design matrix.

Materials. The stimulus materials consisted of line drawings of familiar objects photographed onto slides. See Appendix C for study and test trial lists. The slides were presented using a Kodak Institutional Carrousel slide projector synchronized with an Optisonic Sound-O-Matic I cassette audio tape recorder to supply verbalization in appropriate conditions.

For recognition conditions a booklet was constructed such that each page was comprised of two rows of objects, nine distractors plus the correct response. See Appendix D for an example of a recognition booklet page. The correct response appeared an equal number of times in each position on the page and each object appeared an equal number of times throughout as a distractor. There were thirty randomly ordered pages for each of the two test trials, each set of thirty being constructed independently. In addition, the book contained eight initial pages of items corresponding to two test trials for the pre-experimental practice items. Items on these practice pages did not appear on the experimental study-test trials. Each recognition booklet contained sixty--eight pages.

Procedure. The task for all Ss was the same; to learn a thirty-item list of line drawings of familiar concrete nouns. To insure comparable labeling of the pictorial study and test items in all conditions, all Ss heard the labels of the items presented on a tape. Subjects were seen individually by a white adult male. The study-test method was used. Presentation rate was 10 seconds on the first study trial and five seconds on the second. The rate of presentation was 8 seconds on both the test trials. There was a 10 second inter-trial interval. Each S was seen for approximately 18 minutes.

The sixteen experimental conditions were distinguished in terms of the procedure followed on instructions/examples, on the first pairing trial and on the first test trial only. All Ss were given instructions and four examples appropriate to the condition for which they were selected. (See Appendix E for instructions for each condition). Following these specific instructions, two study-test trials of four pairs were administered. Only Ss who reached a criterion of three out of four correct responses on one of the practice study trials were felt to understand the task and were allowed to continue in the experiment. One child did not meet the performance criterion.

Subjects in recall conditions responded verbally while those in the recognition conditions selected from pictorial items in the recognition book. Subjects in the subject-generate condition were asked to utter their sentences aloud so that E could record them (see Appendix F). The experimenter presented the prompts verbally for Ss in the prompted response conditions.

The four treatment conditions are described below:

1. Empty Control (EC) - The S was given standard PA instructions on the study trial.
2. Subject-Generate (SG) - The S was instructed to form and utter aloud on the first study trial a sentence containing the names of the item pair to be learned.

3. Experimenter-Provide (random) (EP_1) - The S was provided on the initial study trial with a string containing the names of the pair to be learned. These strings were selected at random from the pool of strings generated by Ss in the subject-generate condition. This constitutes a variation of the yoking procedure used by Pelton (1969). The procedure for string selection was:
   a. All strings generated by Ss in the subject-generated condition were recorded by item, with blanks occurring for those Ss who did not generate a string.
   b. One string or blank for each item was selected randomly for the experimenter-provide (random) condition. Through this procedure a list of twenty-eight strings and two blanks was obtained (see Appendix G). All Ss in the experimenter-provide (random) condition received the same set of strings.
4. Experimenter-Provide (criteria) (EP_2) - The subject was provided on the initial study trial with a sentence which met certain specific syntactic and semantic criteria. The sentences were again chosen from the pool of sentences generated by Ss in the subject-generate condition. The semantic and

syntactic criteria were selected from previous findings. The attempt was to select a list of sentences that would maximally facilitate learning of PA's. The criteria were:

a. String was a sentence instead of a phrase (e.g., The boy hit the tree. vs. The boy in the tree).

b. The sentence followed the general form MNVMN (modifier, noun, verb, modifier, noun). For example, either "The brown cow chased the blue ball." or "The cow chased the ball." were acceptable. If no S in the subject-generate condition generated a sentence of the general form MNVMN for a particular item, a sentence of the general form MNVPMN was chosen from the subject-generate pool (modifier, noun, verb, preposition, modifier, noun). Either "The brown cow was near the blue ball," or "The cow was near the ball" were acceptable if a sentence of the form MNVMN had not been generated.

c. Order was critical such that the first noun in the sentence was the stimulus term of the paired associate, the second noun was the

response term. For example, if the item was "cow-ball," then "The cow hit the ball" was an acceptable sentence and "The ball hit the cow" was not.

d. The sentence was grammatically, lexically, and semantically acceptable to a native speaker.

A list of thirty sentences was selected for the experimenter-provide (criteria) condition. All Ss in the provide (criteria) condition heard the same list of sentences. See Appendix H for the list.

Crossed with each treatment condition were the four response conditions, they were:

1. Verbal recall (R_1) - On each test trial S was presented with the stimulus item of each pair and asked to recall its associate.
2. Recall with Prompt (R_2) - On the first test trial the S was prompted with the string he generated or was provided on the initial study trial, with the response term omitted. For example, for the pair "cow-ball," the S may have heard on the initial study trial "cow...ball, the cow chased the ball." On the first test trial he would hear as a prompt, "cow.....the cow chased the_____." The phrase "goes with" was arbitrarily chosen to serve as the prompt for subjects in the EC-R_2 and EC-R_4 conditions.

For example, Ss in these conditions heard "cow goes with_____." as a prompt for the item pair "cow-ball."

3. Recognition (R_3) - The S was presented on the test trial with the stimulus item and was asked to point to the correct response on the page of a response booklet containing the item and nine distractors.

4. Recognition with Prompt (R_4) - The S was prompted on the initial study trial in an identical manner to Ss in R_2; however, he responded in the same manner as the Ss in R_3.

Sentence Rating Procedure

Thirty subjects were seen individually by the experimenter in order to gain the comprehensibility ratings of the sentences used in the experimenter-provide (criteria) condition.

When the S came into the room he was seated at a table. The experimenter sat on the other side of the table facing the S. In front of the S was a board affixed with five 2" x 2" squares of white cardboard with a line-drawn face on each square. The squares had been shaded over with a black crayon in varying degrees moving from left to right.

Therefore, the face on the left most square was completely visible, the face on the card next to it had been shaded over slightly, and so forth until the face on the extreme right was completely obscured. (See Appendix I for diagram). The S was instructed to rate the sentences on "how much sense" they made to him. If they made "complete" sense to him he was to press the "buzzer" with the clear face. If the sentence did not make any sense to him he was to press the "buzzer" with the face completely shaded over. If the degree of sense was somewhere in between, he was to choose from the other "buzzers."

The E then modeled the rating of three sentences.

1. "The houses sleep the trees" (choosing the completely shaded buzzer).
2. "The boy chased the girl" (Choosing the unshaded buzzer).
3. "The girl fell off the dog" (chossing the middle buzzer).

The S was then encouraged to try two examples:

1. "The hat laughed the popcorn."
2. "The man washed the floor."

The subject was felt to understand the task if he chose either of the right of center squares for sentence #1 and either of the left of center squares for sentence #2, and he was allowed to continue in the rating task. All Ss met this criterion.

The sentences were presented using an Optisonic Sound-O-Matic I cassette tape recorder at a seven second interval. Each square had a value assigned to it (clear square=5, shaded square=1, squares in between=2,3,4). Therefore, the comprehensibility rating for a sentence was operationalized as the mean of the choices the 30 Ss made. Each S rated each of the thirty sentences provided in the experimenter-provide (criteria) condition. See Appendix J for the sentence ratings.

CHAPTER III

Results

The dependent variables were the number of correct response nouns recalled or recognized on two test trials.

The paired associate data were scored using a strict criterion, such that an item was correct only if the subject recalled the specific response word.

A multivariate analysis of variance was performed using two sets of planned orthogonal contrasts. The contrasts were formulated in order to test the specific hypothesis of interest. All of the effects were tested with the probability of a type I error at .05. See Appendix K for a discussion of the purpose and nature of orthogonal contrasts.

Table 1 illustrates the planned statistical hypothesis and associated orthogonal coefficients for the hypothesis and associated orthogonal coefficients for the hypotheses involving treatment conditions. For example, contrast Ψ_1 tested whether the population mean for EP_1 differed from the population mean for EP_2. The contrast had the form:

$$\Psi_1 = -(1)\mu_{EP_2} + (1)\mu_{EP_1} + (0)\mu_{SG} + 0\mu_{EC}$$

Insert Table 1 about here

TABLE 1

Statistical Hypotheses and Orthogonal Coefficients

for

Treatment Conditions

		Coefficients For			
		Treatments			Control
		EP_2 (Criteria)	EP_1 (Random)	SG	EC
Contrast	Hypothesis	C_1	C_2	C_3	C_4
$\hat{\Psi}_1$	$H_o: \Psi_1 = 0$ $H_1: \Psi_1 \neq 0$	-1	1	0	0
$\hat{\Psi}_2$	$H_o: \Psi_2 = 0$ $H_1: \Psi_2 \neq 0$	-1/2	-1/2	1	0
$\hat{\Psi}_3$	$H_o: \Psi_3 = 0$ $H_1: \Psi_3 \neq 0$	-1/3	-1/3	-1/3	1

Table 2 illustrates the planned statistical hypotheses and associated orthogonal coefficients for those hypotheses involving response conditions.

Insert Table 2 about here

The following is a statement of the purpose of each orthogonal contrast. The first three contrasts are discussed in reverse order so that the discussion conforms to the statement of the problem.

1. Contrast $\hat{\psi}_3$ was formed to examine the effect of the three treatment groups compared to the control.

   $\hat{\psi}_3 = (-1/3)EP_2 + (-1/3)EP_1 + (-1/3)SG + (1)EC$

2. Contrast $\hat{\psi}_2$ was formed to compare the subject-generate and experimenter-provide treatment groups.

   $\hat{\psi}_2 = (-1/2)EP_2 + (-1/2)EP_1 + (1)SG + (0)EC$

3. Contrast $\hat{\psi}_1$ was formed to compare the experimenter-provide (criteria) and experimenter-provide (random) treatment groups.

   $\hat{\psi}_1 = (-1)EP_2 + (1)EP_1 + (0)SG + (0)EC$

TABLE 2

Statistical Hypotheses and Orthogonal Coefficients

For

Response Conditions

Contrast	Hypothesis	Coefficient for Response Measures			
		R_1	R_2	R_3	R_4
		C_1	C_2	C_3	C_4
$\hat{\Psi}_4$	H_o: $\Psi_4=0$ H_1: $\Psi_4\neq 0$	1/2	1/2	-1/2	-1/2
$\hat{\Psi}_5$	H_o: $\Psi_5=0$ H_1: $\Psi_5\neq$	0	0	1	-1
$\hat{\Psi}_6$	H_o: $\Psi_6=0$ H_1: $\Psi_6\neq 0$	1	-1	0	0

4. Contrast $\hat{\Psi}_4$ was formed to examine whether the learning of PA's differed when the response was recall (including prompted and unprompted recall) vs. recognition (including prompted and unprompted recognition).

$$\hat{\Psi}_4 = (1/2)R_1 + (1/2)R_2 + (-1/2)R_3 + (-1/2)R_4$$

5. Contrast $\hat{\Psi}_5$ was formed to compare the learning of PA's when the response measure was recognition vs. recognition with prompt.

$$\hat{\Psi}_5 = (0)R_1 + (0)R_2 + (1)R_3 + (-1)R_4$$

6. Contrast $\hat{\Psi}_6$ was formed to compare recall vs. recall with prompt.

$$\hat{\Psi}_6 = (1)R_1 + (-1)R_2 + (0)R_3 + (0)R_4$$

The data was analyzed using the multivariate analysis of variance model (MANOVA). The particular computer program used to analyze the data was "MANOVA," which uses the Wilks Lambda Criterion as the multivariate test of significance. The means and standard deviations for the sixteen cells in the design are presented in table 3. See Appendix L for a graphic representation of the cell means.

Insert Table 3 about here

TABLE 3

Means and Standard Deviations of Correct Responses

by

Trial, Treatment Condition, and Response Measure

Response Measure	Treatment Condition	Empty Control		Subject Generate		Experimenter Provide (Random)		Experimenter Provide (Criteria)	
		Trial 1	Trial 2	Trial 1	Trial 2	Trial 1	Trial 2	Trial 1	Trial 2
Recall	$\bar{X}$	4.700	11.400	15.600	22.100	17.400	21.600	16.800	21.700
	S.D.	2.791	4.949	7.090	5.405	6.381	6.328	5.029	5.122
Recall with Prompt	$\bar{X}$	3.700	9.800	20.500	23.600	24.500	25.800	20.800	24.000
	S.D.	2.584	3.676	4.007	5.562	2.461	3.327	5.287	5.598
Recognition	$\bar{X}$	7.100	12.500	22.300	27.500	22.300	24.800	19.700	24.700
	S.D.	3.071	6.241	3.802	2.635	5.417	5.391	5.250	4.832
Recognition with Prompt	$\bar{X}$	7.900	11.300	23.400	27.200	26.100	26.700	25.000	26.900
	S.D.	4.383	4.832	4.402	2.700	2.644	3.199	2.749	2.726

Table 4 presents a summary of the multivariate analysis of variance of the planned comparisons. All of the estimates of the contrasts were found to be significant. None of the interactions between contrasts formed on Factor A (treatment conditions) and Factor B (response conditions) was significant.

Insert Table 4 about here

Examination of the multivariate tests of the contrasts led to rejection of the null hypothesis in all cases. More specifically, the analysis revealed a significant difference between the control condition and the average of the three treatment conditions $\underline{F}$ (2/143)=178.537, $p < .01$. There was also a significant difference between the subject-generate condition and the average of the provide conditions $\underline{F}$ (2/143)=5.078, $p < .01$ and between the experimenter-provide (random condition and the experimenter-provide (criteria) condition $\underline{F}$ (2/143)=4.348, $p < .05$.

Analysis of contrasts involving response conditions revealed a significant difference between the average of the recall conditions and the average of the recognition conditions $\underline{F}$ (2/143)=14.073, $p < .01$. Also significant

TABLE 4

Planned Comparisons Involving Factor A (Treatment Conditions) and Factor B (Response Conditions)

Contrast	df	f
 1	2/143	4.348*
 2	2/143	5.078**
 3	2/143	178.537**
 4	2/143	14.073**
 5	2/143	7.749**
 6	2/143	10.639**

* $p < .05$

** $p < .01$

was the comparison between recognition and recognition with prompt F $(2/143)=7.749, p < .01$, and between recall and recall with prompt F $(2/143)=10.639, p < .01$.

Due to the nature of several of the problems under investigation an analysis of differences between means was insufficient. It was also necessary to determine the direction of the difference.

For example, the elaboration hypothesis implies that scores in an unprompted recall condition would not only be different than scores in a prompted recall condition, but also the unprompted recall scores would be lower than the prompted recall scores. In order to examine this issue of directionality for the various contrasts, estimates of the contrasts were calculated for each dependent variable (Trial 1 and Trial 2). Table 5 contains the estimates of the contrasts.

Insert Table 5 about here

To interpret the estimates of the contrasts, it is necessary to refer to the form of each contrast, particularly to the signs of the coefficients. For example, contrast Ψ_3 had the form

$$\Psi_3 = -1/3\ (\mu_1 + \mu_2 + \mu_3) + (1)\ \mu_4 = 0$$

TABLE 5

Estimates of Contrasts and Univariate Tests of Significance

Contrast	Trial 1	Trial 2
 1	2.000*	.400
 2	-1.125*	.575
 3	-15.350**	-13.467**
 4	-3.725**	-2.700*
 5	-2.750**	- .650
 6	-3.750**	-1.600

* $p < .05$

** $p < .01$

where μ'_1, μ'_2, μ'_3 are the population means of the treatment conditions and μ'_4 is the population mean of the control condition.

The form of the contrast Ψ_3 implies that if the estimate of Ψ_3 is negative, then the term

$$-1/3\ (\mu'_1 + \mu'_2 + \mu'_3) \text{ is greater than } (1)\ \mu'_4.$$

By referring to Table 5, it can be seen that this is the case, for both test trials the estimate of Ψ_3 was negative. Therefore, it can be inferred that not only did the treatment groups differ from the control, but they differed in a positive direction. Similarly, the estimate of Ψ_2 shows that scores in the experimenter-provide conditions were higher than scores in the subject-generate condition on test trial 1 while the reverse was true on test trial 2. Estimates of Ψ_1 imply scores were higher in the experimenter-provide (random) condition than in the experimenter-provide (criteria) condition.

The estimate of Ψ_4 shows that scores were higher in the recognition conditions than in the recall conditions for both test trials. Estimates of Ψ_5 and Ψ_6 imply that scores were higher in prompted conditions than in unprompted conditions.

It should be remembered that the multivariate tests of significance take into account two scores for each subject in the present experiment. Therefore, when a significant difference is found between means, say for experimenter-provide and subject-generate, the difference may be due to both of the scores or one score alone. Multivariate tests exist for examining the relative contribution of each variable in a multivariate study when an overall test is found to be significant, most notably, the Roy-Bose technique for establishing simultaneous confidence intervals (Morrison, 1967). Such confidence intervals require a different test statistic (largest characteristic value) than the statistic used in this program. The program employed the Wilks Lambda Criterion as the test statistic for the multivariate tests of significance.

Under the circumstances, it was felt that the univariate tests of significance for the various contrasts would yield similar information. Such univariate tests should be interpreted with caution if the corresponding multivariate test was not significant. In this analysis all corresponding multivariate tests were significant.

The MANOVA program computes univariate F ratios for each dependent variable after it computes the multivariate F for each contrast. The asterisks in Table 5 denote the probability levels for the F ratios (univariate F) for each contrast.

It is clear, for example, by referring to Table 5, that where differences exist between levels of treatment, the differences are more pronounced for Trial 1 than Trial 2. This creates the impression that the major impact of various treatments was on performance on Trial 1, a natural enough phenomenon since the children were only provided with, or told to generate, sentences on the first study trial.

Relationship Between Rated Comprehensibility and Performance

Comprehensibility ratings of the sentences provided in the experimenter-provide (criteria) condition were obtained. The comprehensibility rating for each sentence was then correlated with the number of correct responses for each item in the provide-criteria condition. The correlation thus reflects the relationship between the rated comprehensibility of a sentence and the degree to which the sentence facilitated learning in the provide (criteria)

condition. The correlation was determined between rated comprehensibility and number of correct responses for each test trial. The correlation in both cases was extremely high. Table 6 gives the matrix of the correlations formed.

Insert Table 6 about here

TABLE 6

Correlations Between Rated Comprehensibility

and

Number of Correct Responses - Two Test Trials

Rating	Trial 1	Trial 2
1.0	.92	.89
	1.0	.93
		1.0

CHAPTER IV

Discussion

Bean and Rohwer (1973) previously compared subject-generate and experimenter-provide treatments with young children. The present study replicated their finding that subject-generate and experimenter-provide treatments facilitate learning relative to a control condition. However, Bean and Rohwer found no significant difference between a subject-generate and experimenter-provide condition. This conflicts with the present finding in that scores in the subject-generate condition differed significantly from scores in the experimenter-provide conditions. There are certain design differences between the two studies. Most significantly, in the previous study the PA items were presented aurally, while the present study presented the Ss with pictures and aural labels of the PA items. Lynch and Rohwer (1971) found that associative matching was higher in a picture condition than in a word condition, especially when the PA item was accompanied by a sentence context. While presentation modality was not a variable of interest in the present study, the Lynch and Rohwer (1971) study and the present results suggest the possibility that presentation and treatment modalities may interact.

The direction of the difference between experimenter-provide and the subject-generate conditions is a slightly murky issue. The estimates of the contrast comparing these conditions imply that experimenter-provide scores are higher than subject-generate scores for the first test trial, while the reverse is true for the second trial. However, the univariate analysis implied that the relationship found for trial one contributed most significantly to the overall multivariate difference.

It seems that scores in the experimenter-provide conditions were higher than subject-generate scores for test trial one, and there was no significant difference between them on test trial two. While the greater facilitation of experimenter-provided relative to subject-generated strings was implied by the Kerst and Levin (1972) study, alternative explanations of the cause of the relationship are possible. Either young children are relatively incapable of generating elaborations, or the experimenter-provide treatment interacts with some other experimental variable in order to facilitate learning. Since a yoking procedure was used in the present study, the explanation that children do not generate elaborations is

unattractive means of explaining the difference between provide and generate. Rather, hypotheses that test a Treatment X Presentation modality interaction should be explored.

The data also revealed a significant difference between the experimenter-provide (random) and experimenter-provide (criteria) conditions. Strings provided in the random condition were selected from the subject-generated pool of strings, while sentences in the criteria condition were selected from the same pool according to a set of syntactic and semantic criteria.

The difference between the groups is of interest for a variety of reasons. If it had been shown that the provide (criteria) strings facilitated learning to a greater degree than the provide (random) strings, the criteria by which the strings were selected would have been validated. That is, it would have been clear that the generalizability of previous findings concerning certain syntactic and semantic properties of strings had been increased.

However, the strings which were selected at random facilitated performance to a greater degree than those strings selected to meet certain syntactic and semantic criteria. It is difficult to interpret this finding.

One possible explanation centers on the notion of task novelty as a variable affecting S attention. All the strings provided in the criteria condition were of the form MNVMN. This may have created, in a sense, an uninteresting list of strings, all of which began to sound the same to the subjects. The randomly selected set of strings exhibited a wider range of syntactic constructions. Perhaps the varied form of the randomly chosen strings is a critical factor in that their relative number of different sentence forms increased some variable such as S attention to the task.

What is clear is that the particular set of criteria used to determine the list of strings for the provide (criteria) condition did not create a list of provided strings which facilitated learning more than a list of strings selected at random.

The findings concerning variations in response measure support the assumption that elaboration is the critical factor in noun pair learning. To review, the elaboration assumption implies that scores when the response measure is recognition should be higher than scores when the response measure is recall. Further, scores in prompted response conditions should be higher than scores in

unprompted condition, if the prompt is of the type which would facilitate the regeneration of the elaborated event. In general, all the significant differences and their directions found in the present study are implied by the elaboration assumption. In addition, the finding that scores in the recognition condition were lower than scores in prompted recognition supports the assumption that recognition and prompts facilitate the regeneration of the elaborated event in different ways; recognition by insuring the availability of the response term, and prompts by restating the original event minus the response term.

The correlation between rated comprehensibility of the strings provided in the experimenter-provide (criteria) condition and the degree to which they facilitated learning is extremely interesting, yet difficult to interpret. The correlation suggests that the "comprehensibility" of a provided string is positively related to its facilitation power. This has face validity. Children may be more likely to store strings which make more sense to them. Therefore, those strings are more likely to facilitate performance than strings which do not make sense, since the latter strings may not be remembered. However, an examination of the sentences provided, coupled with their

ratings (see appendix J) clouds the issue. For example, the three sentences receiving the highest ratings were: 1. The axe chopped the kite. (4.33). 2. The mouse rang the bell (4.12). and 3. The candle hit the iron (4.10). The three sentences rated lowest were: 1. The key is under the pillow (1.65). 2. The toy ship was in the buggy (1.97). and 3. The pipe was near the fish (2.0). It's difficult to understand why "The candle hit the iron" makes more sense than "The key is under the pillow." In fact, these ratings suggest that perhaps the children were rating the sentences on some sort of "action" continuoum. Those sentences implying action received the highest ratings. Alas, "The pencil stabbed the cake" received the relatively low rating of 2.13, and "The dress was on the bird" was rated rather high (3.77). Therefore, it is difficult to interpret the high correlations obtained.

It should be noted that the system of rating the sentences seemed to be easily understood by the children. The difficulty lies in interpreting why certain sentences "made more sense" than others. The correlation suggests that when syntactic form is held relatively constant,

there is some semantic variable of provided strings which predicts success. An appropriate test would involve the experimental manipulation of rated meaningfulness, perhaps through a mixed-list design.

The results of this study have educational implications. They support the powerful effect that induced (subject-generated) and imposed (experimenter-provided) verbal elaborations have on the learning of PA's in young children. It is clear that verbal elaboration of the stimulus materials in the PA task greatly facilitated learning in young children.

While it is difficult to draw parallels between performance on a PA task and performance in an educational setting, the results certainly suggest that teachers of young children should be made aware of the powerful effect of elaboration on performance.

For example, a major educational task in beginning reading is to associate an arbitrary sound with an arbitrary symbol. At face value the learning of such information as "a" sounds like "aah" seems similar to the task of learning a paired associate. It may be that inducement or imposition of an elaboration strategy would facilitate such learnings.

The tentativeness of this implication highlights the need for future research examining the relationship between research using the paired-associate paradigm, and the pressing needs of practical education. Davidson (1970) has cautioned experimenters involved in basic research against implying that the results of basic research have direct implications for the "real" world of education.

Davidson (1970) reviewed the work of four men (Bower, Frase, Rohwer and Paivio) who have directed major research programs utilizing basic PA learning paradigms to examine issues of elaboration, imagery, and memory. For Davidson, the core of the issue involved the extent to which tuition should take the form of induced learning. This is to say, materials presented to children might be structured linguistically, mneumonically or pictorially in ways that would insure learning.

Davidson argues that such tuition would not sustain the child in the absence of the special materials, and rather, information from basic research should be translated into teachable cognitive strategies. The notion is that it should be possible to teach the child to generate his own linguistic structures, his own mneumonics, and his own effective images, thus creating an "independent learner."

While Davidson's discussion is fascinating in its potential for hypothesis generation, it seems to rest on a prior assumption about the relationship between basic research and the educational setting. Essentially, Davidson is discussing the form that research relating basic learning research and education should take, before the viability of either an "induced" or "independent learner" approach has been documented. It seems unwarranted to limit the direction that research relating basic research to education should take until the viability of such research has been explored. What is envisioned is a broad research program exploring the "carry over" of findings from basic research to the applied educational setting. For example, the amount of induced learning provided by imposing linguistic structures in the present experiment was not trivial <u>within the paired associate paradigm</u>. A logical extension of the present study would now be to examine the same parameters with an applied task; perhaps a phonics task as discussed previously. This is not to say that it would not be equally viable to attempt to train children to generate their own mneumonics spontaneously when presented with an applied task.

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APPENDIX A

Formal Statement of Major Hypotheses and Planned Comparisons

μ denotes the population mean in all cases.

1. There will be no difference in the degree to which (EP) and (SG) treatments and a control group aid learning.

$H_0: \mu EC - (1/3\,\mu SG + 1/3\,\mu EP_1 + 1/3\,\mu EP_2) = 0$

$H_1: \mu EC - (1/3\,\mu SG + 1/3\,\mu EP_1 + 1/3\,\mu EP_2) \neq 0$

2. There will be no difference in the degree to which (SG) and (EP) treatments aid learning.

$H_0: \mu SG - (1/2\,\mu EP_1 + 1/2\,\mu EP_2) = 0$

$H_1: \mu SG - (1/2\,\mu EP_1 + 1/2\,\mu EP_2) \neq 0$

3. There will be no difference in the degree to which (EP_1) strings and (EP_2) strings facilitate learning.

$H_0: \mu EP_1 - \mu EP_2 = 0$

$H_1: \mu EP_1 - \mu EP_2 \neq 0$

4. There will be no difference in learning measured by recall (including prompted and unprompted recall) and recognition (including prompted and unprompted recognition).

$H_0: (1/2\,\mu R_1 + 1/2\,\mu R_2) - (1/2\,\mu R_3 + 1/2\,\mu R_4) = 0$

$H_1: (1/2\,\mu R_1 + 1/2\,\mu R_2) - (1/2\,\mu R_3 + 1/2\,\mu R_4) \neq 0$

APPENDIX A (continued)

5. There will be no difference in learning measured by recall and recall with prompt.

$H_0: \mu_{R_1} - \mu_{R_2} = 0$

$H_1: \mu_{R_1} - \mu_{R_2} \neq 0$

6. There will be no difference in learning measured by recognition and recognition with prompt.

$H_0: \mu_{R_3} - \mu_{R_4} = 0$

$H_1: \mu_{R_3} - \mu_{R_4} \neq 0$

APPENDIX B

Design of Experiment

Factor A
Treatment Condition

Factor B: Response Mode \ A	EP_2	EP_1	SG	EC
Recall (R_1)	$\underline{X}_{111}$:	X_{211} · ·	· ·	$\underline{X}_{411}$ ·
Recall with Prompt (R_2)	$\underline{X}_{121}$ ·			· · · ·
Recognition (R_3)	· · · ·			· · · ·
Recognition with Prompt (R_4)	X_{141} · ·	· ·	· · ·	X_{441} · · $X_{44(10)}$ · · ·

10 observations/cell - Total observations=160

$$\underline{X}_{ijk} = \begin{bmatrix} X_{ijk1} \\ X_{ijk2} \end{bmatrix}$$

Where i= level of Factor A
j= level of Factor B
k= # of subject

APPENDIX C

Study and Test Trial Lists in Order Presented

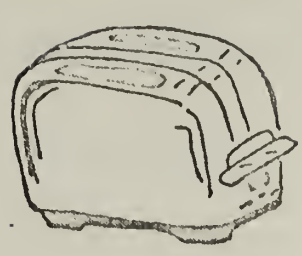
	Study Trial #1	Test Trial #1	Study Trial #2	Test Trial #2
1.	picture-mailbox	brush...	jar-rope	flower...
2.	candle-iron	axe...	axe-kite	arrow...
3.	mouse-bell	rocket...	lightbulb-ladder	airplane...
4.	lightbulb-ladder	ship...	drum-tree	shovel...
5.	shovel-bed	candle...	dress-bird	ship...
6.	jar-rope	baby...	airplane-toaster	drum...
7.	ring-lamp	pencil...	lock-book	shoe...
8.	dress-bird	mouse...	mouse-bell	rug...
9.	airplane-toaster	arrow...	rocket-hotdog	axe...
10.	rocket-hotdog	picture...	candle-iron	top...
11.	flower-cup	key...	rug-pitcher	baby...
12.	ship-buggy	tractor...	arrow-glasses	butterfly...
13.	drum-tree	top...	telephone-wagon	tie...
14.	rug-pitcher	jar...	key-pillow	tractor...
15.	pipe-fish	shoe...	flower-cup	brush...
16.	key-pillow	flower...	baby-umbrella	pipe...
17.	clock-swing	tie...	shoe-chair	pencil...
18.	baby-umbrella	lightbulb...	butterfly-whistle	clock...
19.	lock-book	ring...	clock-swing	telephone...
20.	toothbrush-basket	lock...	top-moon	candle...
21.	top-moon	shovel...	pipe-fish	jar...

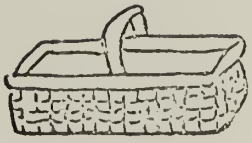
APPENDIX C (continued)

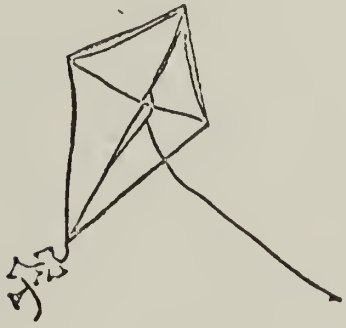
	Study Trial #1	Test Trial #1	Study Trial #2	Test Trial #2
22.	arrow-glasses	clock...	brush-skate	ring...
23.	pencil-cake	rug...	picture-mailbox	dress...
24.	tie-cow	dress...	tie-cow	key...
25.	brush-skate	telephone	ship-buggy	lock...
26.	telephone-wagon	toothbrush...	ring-lamp	rocket...
27.	butterfly-whistle	pipe...	toothbrush-basket	mouse...
28.	tractor-apple	airplane...	pencil-cake	lightbulb
29.	axe-kite	butterfly...	shovel-bed	toothbrush...
30.	shoe-chair	drum...	tractor-apple	picture...

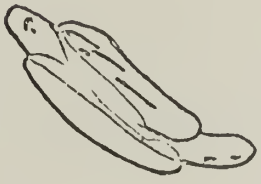
APPENDIX D

Example of Response Booklet Page









APPENDIX E

Instructions and Procedures for Each Experimental Condition

General Instructions

Let me tell you what I want you to do today, but first let me tell you what I've done. I divided a group of pictures into pairs of two pictures each...so that we have 30 pairs of pictures of common things you already know, like a picture of a door and a picture of a lamp. When you see the pictures of the pair of things like "door" and "lamp" you will also hear their names on the tape recorder. Each pair will be followed by a bell to tell you the next pair is coming up. (Specific instructions for conditions) After you see all the pictures once, you will see the same pictures again but with one picture missing. Your job will be to tell me (point in your booklet to) the missing picture. Let me give you some examples (give appropriate example). (At the initiation of the test trial) Now you will see and hear one word only: tell me/point in your booklet to/the missing picture.

Empty-Control (EC)

When you see the picture of two things and hear their names, your job will be to remember the two things that go together.

APPENDIX E (Continued)

Provided Conditions (EP_1, EP_2)

You will see a picture of two things and hear their names, then you will hear a sentence for each pair. Your job will be to listen to the sentence and remember the two things that go together.

Subject Generate (SG)

You will see a picture of two things and hear their names, your job will be to put the two names into a sentence. Then say the sentence aloud and remember the two things that go together.

Response With Prompt (R_2, R_4)

All subjects in EC-R_2 and EC-R_4 heard "What goes with (stimulus)?" as a prompt on the first test trial. This procedure was followed for those items in SG-R_2, SG-R_4, EP_1-R_2, and EP_1-R_4, where the subject did not generate a task relevant verbalization.

APPENDIX F

Subject Generate Strings

Two Examples Chosen at Random From the Pool of Forty Subjects in the Subject-Generate Condition

Barry 20

1. The picture is hanging on the mailbox
2. The iron is next to the candle
3. The mouse went in the bell
4. Somebody took lightbulb and stood on the ladder to put it in
5. The shovel's on the bed
6. The rope is next to the jar
7. The ring is on the lamp
8. The bird sat on the dress
9. The airplane has a toaster inside
10. The hotdog's in the rocket
11. The flower's in the cup
12. The buggy's in the ship
13. The drum is next to the tree
14. The pitcher's on the rug
15. The fish caught the pipe
16. The key's on the pillow
17. The clock fell on the swing

APPENDIX F (Continued)

18. The baby's holding the umbrella
19. Blank
20. The lock is on the book
21. The toothbrush is in the basket
22. The top was outside and the moon shined on it
23. Somebody shot an arrow through the glasses
24. The cake is next to the pencil
25. The cow has the tie in its mouth
26. The skate's on the brush
27. The telephone is in the wagon
28. The butterfly saw the whistle
29. The tractor rolled over the apple
30. The axe chopped the kite
31. The shoe is in the chair

Linda 7

1. I saw the picture put it in the mailbox
2. I light the candle so I can see while I ironed
3. Mouses don't like the sound of a bell
4. My father used a ladder to put up the lightbulb
5. I dreamed in my bed I was shoveling
6. I put the rope in the jar

APPENDIX F (Continued)

7. I turned on a lamp to see if my ring was bright
8. I put on a dress looked out the window and saw a bird
9. An airplane is louder than a toaster
10. My brother stuck the hotdog with his rocket
11. A flower needs water so I put it in the cup
12. My little brother sat in the buggy and saw a ship in water
13. I played the drum under the tree
14. I sat on the rug and poured juice from the pitcher
15. I smoked my pipe and watched fish in the sea
16. I took my key and put it under my pillow
17. I have to go in at 8 o'clock to swing
18. The baby likes to go under the umbrella
19. I took my lock and put it in my book
20. I put the brush in my basket
21. I spin my top under the moon
22. My arrow hit my glasses
23. I put my pencil in the cake
24. I put on my tie and then milked the cow
25. I fell over my brush and my skate
26. I rode my wagon and put my telephone into it
27. I watched my butterfly blow my whistle

APPENDIX F (Continued)

28. I ate my apple on my tractor
29. My little brother flew his kite and I cut the wood with my axe
30. I put on my shoe and sat in my chair

APPENDIX G

Strings Provided in (EP_1) Treatment Condition

1. A picture was in the package and I put it in the mailbox.
2. By accident somebody put the candle near the iron.
3. I have a pet mouse and Mom has a new bell.
*4. A man was standing on the ladder fixing the light (bulb).
5. You can shovel the driveway with a shovel and sleep in a bed.
6. Top goes with moon.
7. The ring is on top of the lamp.
8. I put on a dress and looked out the window and saw a bird.
*9. The toaster was in the airplane.
10. They stopped the rocket to get a hotdog.
11. The flower's in the cup.
*12. The buggy was in the ship.
13. The drum was in the tree.
*14. The pitcher fell on the rug.
*15. The fish is smoking the pipe.
16. The key was under the pillow.
17. Someone put a lock on the book.
18. The baby is too little to use the umbrella.
19. Someone put a lock on the book.

APPENDIX G (Continued)

20. The toothbrush was in the basket.
21. Jar goes with rope.
22. The arrow went right through the glasses.
23. I put my pencil in the cake.
24. The cow is wearing the tie.
*25. I used to have skates and I have a brush at home.
*26. The wagon carried the telephone.
*27. Cops use whistles and butterflies fly.
*28. There's apples in the tractor.
29. Somebody chopped the string with the axe and the kite flew away.
30. The shoe's on the chair.

*Denotes stimulus and response nouns in reverse order

APPENDIX H

Sentence Provided in (EP_2) Treatment Condition

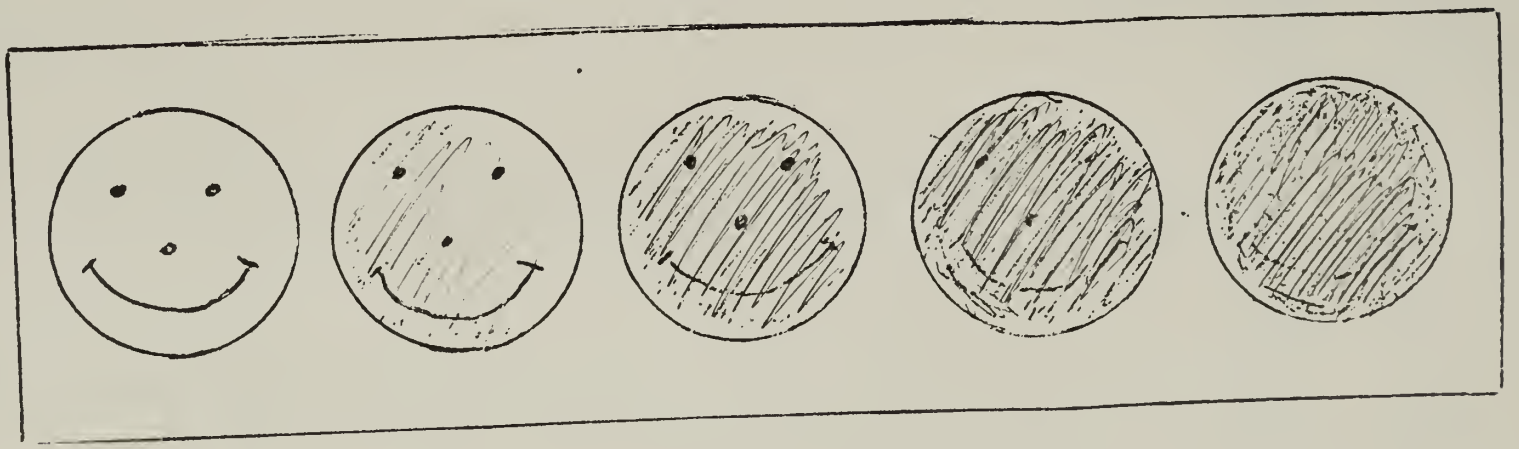
1. The picture was in the mailbox.
2. The candle hit the iron.
3. The mouse rang the bell.
4. The lightbulb fell off the ladder.
5. The shovel was under the bed.
6. The jar was tied to the rope.
7. The ring was on the lamp.
8. The dress was on the bird.
9. The airplane has a toaster in it.
10. The rocket smashed the hotdog.
11. The flower was in the cup.
12. The toy ship was in the buggy.
13. The drum is caught up in the tree.
14. The rug is near the pitcher.
15. The pipe was near the fish.
16. The key is under the pillow.
17. The clock fell off the swing.
18. The baby is holding the umbrella.
19. The lock is on the book.
20. The toothbrush was in the basket.

APPENDIX H (Continued)

21. The top is spinning around the moon.
22. The arrow went through the glasses.
23. The pencil stabbed the cake.
24. The tie is on the cow.
25. The brush was on the skate.
26. The telephone is in the wagon.
27. The butterfly blew the whistle.
28. The tractor ran over the apple.
29. The axe chopped the kite.
30. The shoe dropped on the chair.

APPENDIX I

Diagram of Sentence Rating Board



APPENDIX J

Rated Comprehensibility of Sentences and Number of Correct Responses for Two Test Trials

Sentence # (Corresponds to List in Appendix H)	Rating	# Correct Trial 1	# Correct Trial 2
1	3.36	32	34
2	4.10	26	36
3	4.12	30	32
4	3.13	31	35
5	2.83	35	36
6	2.41	28	30
7	3.33	18	25
8	3.77	28	34
9	3.19	21	32
10	2.23	30	32
11	2.06	33	39
12	1.97	31	36
13	3.77	32	36
14	2.16	18	33
15	2.00	16	23
16	1.65	28	29
17	3.32	24	34
18	2.19	36	38

APPENDIX J (Continued)

Sentence # (Corresponds to List in Appendix H)	Rating	# Correct Trial 1	# Correct Trial 2
19	3.10	22	27
20	2.71	26	33
21	2.42	35	34
22	2.97	26	30
23	2.13	28	28
24	3.72	29	36
25	3.52	21	25
26	2.55	23	29
27	3.13	31	32
28	3.65	36	40
29	4.33	34	28
30	3.06	29	34

APPENDIX K

Discussion of Orthogonal Contrasts

Planned Comparisons

Within the context of analysis of variance (either multivariate or univariate) it is possible to formulate and test specific hypotheses other than the general overall hypothesis of equal treatment effects. This involves the technique of planned comparisons. For example, instead of testing the null hypothesis:

$$H_{01}: \mu_1 = \mu_2 = \mu_3 = \mu_4 = 0$$

where μ_1, μ_2, μ_3, and μ_4 are the population means.

With four treatment groups, it is possible to form a hypothesis such as:

$$H_{01}: \mu_1 - 1/3\,(\mu_2 + \mu_3 + \mu_4) = 0$$

VS.

$$H_{11}: \mu_1 - 1/3\,(\mu_2 + \mu_3 + \mu_4) \neq 0$$

Here the hypothesis being tested is that population mean of treatment group #1 equals the average of the other three treatment groups. The left hand sides of the above equations are in the form:

$$\underline{\Psi} = C_1 \quad _1 + C_2 \quad _2 + C_3 \quad _3 + C_4 \quad _4$$

APPENDIX K (Continued)

where the C's are constants. This linear combination of the means is called a comparison. In most applications, only comparisons with the property:

$$\sum_j C_j = 0 \quad (_j = \# \text{ of population means})$$

are of interest since they are estimable. Comparisons with this property are known as contrasts. The expression

$$\Psi = \sum_j C_j \mu_j$$

is called a population contrast.

The sample contrast is estimated by:

$$\hat{\Psi} = \sum C_j \bar{X}_j$$

are the expected value of $\hat{\Psi} = \Psi$ (where E is the normal expected value operator). Therefore, $\hat{\Psi}$ is an unbiased estimate of the population contrast Ψ.

If the experimenter is interested in answering a set of questions (as in the present experiment), each corresponding to some comparison among means, the problem of independent comparisons arises. Suppose in a study with three experimental groups, the experimenter decides to test the following contrasts:

APPENDIX K (Continued)

$$\Psi_1 = \mu_1 - \mu_2$$

$$\Psi_2 = \mu_1 - \mu_3$$

$$\Psi_3 = \mu_2 - \mu_3$$

These contrasts are not independent since Ψ_3 is simply the difference between Ψ_1 and Ψ_2. This fact has serious consequences for estimates and tests, since the questions involved in the respective comparisons cannot be given separate and unrelated answers unless the comparisons are statistically independent.

Given two contrasts

$$\hat{\Psi}_r = C_{r1}\bar{X}_1 + C_{r2}\bar{X}_2 + \ldots + C_{rj}\bar{X}_j$$

and

$$\hat{\Psi}_s = C_{s1}\bar{X}_1 + C_{s2}\bar{X}_2 + \ldots + C_{sj}\bar{X}_j$$

it can be shown that the two contrasts are independent if and only if

$$\sum_{j-1}^{J-1} \frac{C_{rj}\,C_{sj}}{n_j} = 0$$

APPENDIX K (Continued)

If all the n_j's are equal, the above condition reduces to

$$\sum_{j=1}^{n} C_{rj} C_{sj} = 0$$

Contrasts that are independent are known as orthogonal contrasts.

For the present experiment, planned comparisons involving factor A (levels of treatment) and factor B (types of response mode) were examined by developing sets of orthogonal contrasts.

APPENDIX L

Cell Means as a Function of Response Mode and Treatments